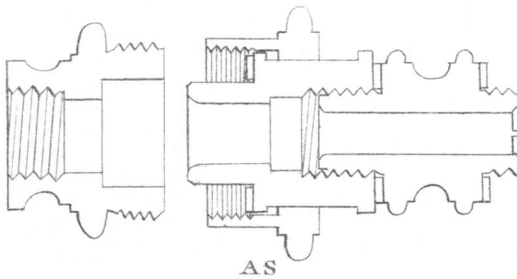
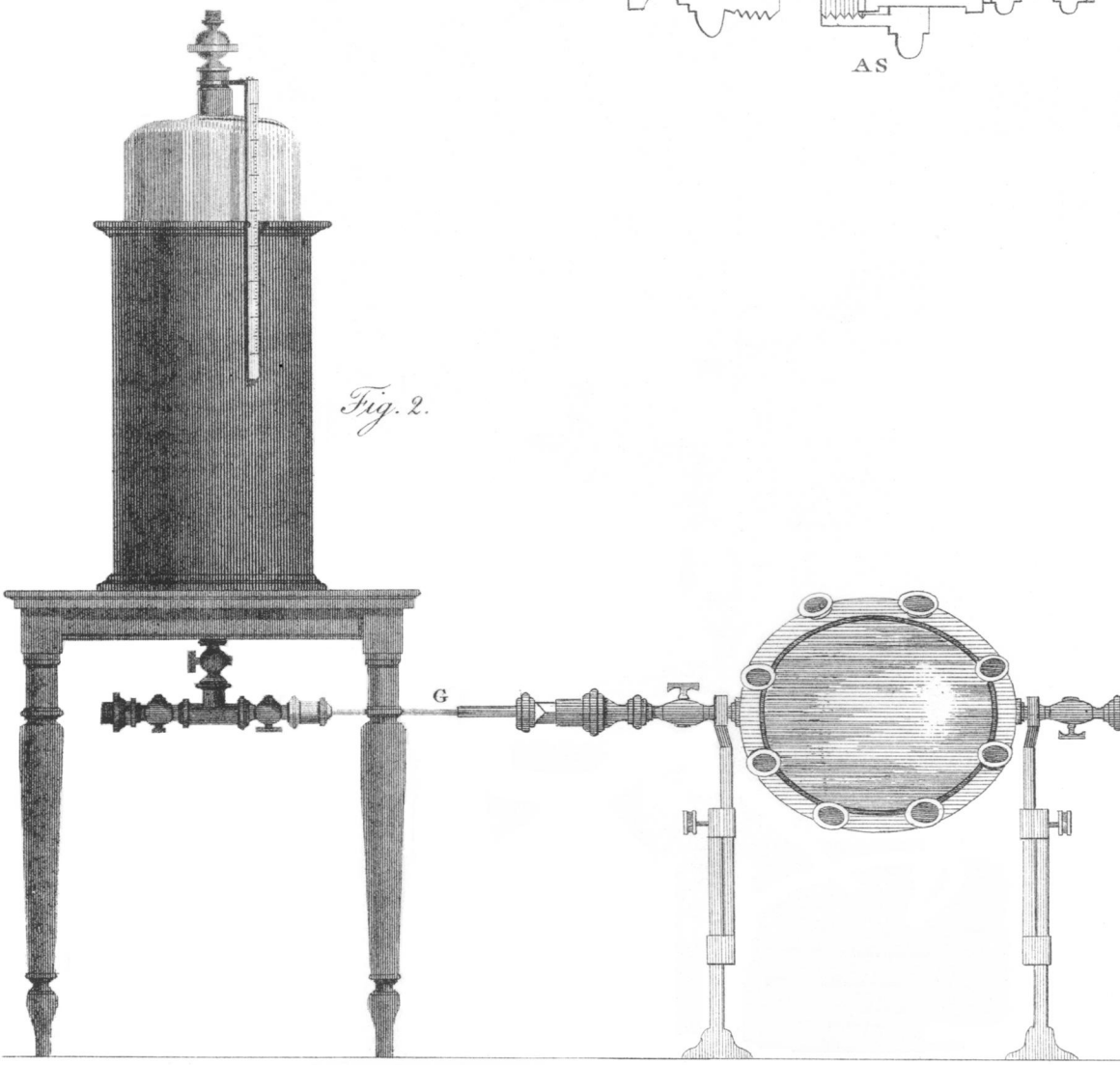


Fig. 2.



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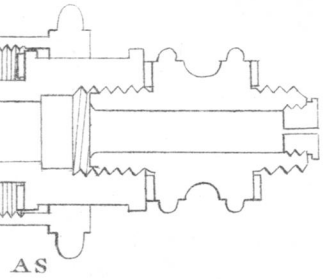

Fig. 1.

Basire Sc.

XIV. *On the Respiration of the Leaves of Plants.*

By William Hasledine Pepys, *Esq.*, *F.R.S.*

Received April 8,—Read May 25, 1843.

AFTER I had written, in conjunction with my friend Mr. Allen, the papers which were published in the Philosophical Transactions for 1808, 1809 and 1829, on the Respiration of Man, the Graminivorous Animals and Birds, showing the deterioration of the atmospheric air by the quantity of carbonic acid gas produced, I instituted a series of experiments on the respiration of plants, and particularly of their leaves. The difficulty of obtaining, for this purpose, specimens which had been previously accustomed to respire constantly under a glass inclosure, and to maintain all their functions in that situation, was overcome by my obtaining possession of a few fine specimens of fig- and vine-trees, which had been under glass culture for a number of years.

To obviate the errors which might arise from making the experiments over water, the apparatus which I formerly used in the combustion of the diamond and other carbonaceous substances was employed, and a modification of the mercurial gasometers, with an appendage consisting of a pair of concave glasses, which formed, when united, an oblate spheroid, was found most useful in the investigation of the nature and chemical composition of the atmospheric air which had served the purpose, first of animal, and then of vegetable respiration.

The pair of concave glasses above mentioned were secured in strong brass rims, well and accurately ground together; and, to prevent their separating when in use, eight brass screws were attached to the rims. There were also three openings in the rims, for the purpose of forming a communication with the gasometers, and with the plant or leaf which was the subject of the experiment.

The mercurial gasometers having been already described and figured in the paper published in the Philosophical Transactions for 1807, it will not be necessary here to repeat their description, but a representation of the oblate spheroid, in which the plant subjected to the experiment was confined, is given, in connexion with the mercurial gasometers, in the annexed Plate XVIII.

The following is the journal of the experiments which I made with this apparatus:—

July 16th, 1838.

From a large mercurial gasometer, connected with the two smaller and the glass hemispheres, I passed 100 cubic inches of respired air, which I suffered to escape by one of the small gasometers after it had been through the hemispheres; I

then admitted fifty-two cubic inches from the large gasometer to one of the small ones; I then passed and repassed the respired air several times through the hemispheres, and on examination found it to contain eight parts in the 100 of carbonic acid.

July 19th.—Barometer 30·220. Thermometer 72°.

I enclosed with great care a fig-leaf between the glass hemispheres, and secured the stem by a grooved split cork, cemented by a strong solution of gum-arabic; I then passed 100 cubic inches of respired air (containing eight parts in the 100 of carbonic acid) through the hemispheres containing the fig-leaf, and let that air escape; I then received into one of the small mercurial gasometers fifty-three cubic inches of the respired air, and passed it through the hemispheres into the other small mercurial gasometer; from thence it was returned, and on examination was found to contain 8 per cent. carbonic acid. I then passed and repassed the respired air over the leaf in the hemispheres, allowing five minutes for each passage. After ten repetitions in this way, I examined the state of the respired air, and found 6 per cent. carbonic acid. I had used in the examination eight cubic inches. The forty-five cubic inches of respired air was now passed and repassed, as before, over the leaf in the hemispheres ten times, five minutes being allowed for each passage. The respired air was then examined, and found to contain 5 per cent. carbonic acid. The respired air was then left in the hemispheres and the two small gasometers until the next morning, at 11 o'clock; on examination it was found to contain 3 per cent. carbonic acid. Many more experiments were made that same year, and with little variation in their results.

July 4th, 1839.—Barometer 30·200. Thermometer 74°.

I repeated the experiment of the 19th of July, 1838, with the same care and attention. On the first examination of the respired air after ten passings and repassings over the fig-leaf in the glass hemispheres (five minutes being allowed for each passage), the respired air containing 8 per cent. carbonic acid at the commencement, I found 6 per cent. carbonic acid, two parts having disappeared.

The process was then continued as before described, and on the second examination I found $4\frac{1}{2}$ per cent. carbonic acid in the respired air. The next morning, the air having been left as before, and the fig-leaf having remained in the hemispheres connected with the two small gasometers, I found on examination, $2\frac{1}{2}$ per cent. carbonic acid.

It may be requisite here to state, that the respired air which was left after the action of the fig-leaf, was also examined by the charged solution of green sulphate of iron and nitrous gas, as to its quantity of oxygen, and gave the usual volume of oxygen for the carbonic acid gas that had disappeared.

The above experiments were repeated with little alteration in their result. The fig-leaves that had been confined in the air were all in as good health as the others on the same tree. A mark had been kept upon them, and I sometimes used the same leaf again.

July 14th, 1840.—Barometer 30·300. Thermometer 59°.

I repeated the experiment of the 19th of July, 1838, and, on the first examination of the respired air, found 6 per cent. carbonic acid, the respired air having contained 8 per cent. at the commencement.

The process was then continued much quicker than before for twenty-five minutes, and on examination of the air, I found 5 per cent. carbonic acid.

On examining the respired air the next day I have generally found it reduced to 2 per cent. carbonic acid.

I repeated the experiment, using a fine healthy vine-leaf in place of the fig-leaf, and secured with the same precaution. I found the vine-leaf not so active an agent as the fig-leaf. The respired air, which at the commencement of the experiment gave 7 per cent. carbonic acid, after two hours, and passing and repassing fifty times, on examination was found to contain 5 per cent. carbonic acid.

A vine-leaf was secured in the glass hemispheres, and the small mercurial gasometers were supplied with atmospheric air, which was passed and re-passed at intervals for two nights and one day. On examining the atmospheric air that had been thus treated, I found that no carbonic acid had been formed, nor was there any alteration in the quantity of oxygen.

A vine-leaf was secured in the glass hemispheres, the mercurial gasometers were connected, and the atmospheric air which they contained was passed and re-passed at intervals. At the end of fourteen days the leaf changed colour in patches of yellow, until, at the conclusion of three weeks from its introduction, it became almost entirely yellow. On examining the atmospheric air, I found that it contained 2 per cent. carbonic acid, and nearly half an ounce measure of fluid had condensed in the hemispheres; the addition of lime water to the fluid produced no turbidness.

During the months of June and July, 1841, I pursued the same train of experiments upon the fig-leaves in the hemispheres of glass, as before described, using respired atmospheric air, and obtained similar results as to the abstraction of the carbonic acid gas and the restoration of the oxygen.

The trees were in good health and ripened their figs as usual.

April 21st, 1842.—Barometer 30·182. Thermometer 62°.

Having secured a fine healthy leaf of the fig-tree in the glass hemispheres connected with the mercurial gasometers, I passed 150 cubic inches of respired air, containing 8 per cent. of carbonic acid gas, through the small gasometers and the hemispheres, and then liberated it. I then passed fifty-five cubic inches of the respired air from the large mercurial gasometer into the small one, and from thence through the hemispheres into the other small gasometer, and back again: on examining this air, I found 8 per cent. carbonic acid gas.

I then passed and repassed the air ten times, taking five minutes for each passage, and on examining the air found $6\frac{1}{2}$ per cent. carbonic acid gas. The respired air was

then passed and repassed occasionally for about three hours, when it was examined, and found to contain 4 per cent. carbonic acid.

The hemispheres were then left open to the two small gasometers during the night, and on the morning of the 22nd of April (barometer 30·042, thermometer 61°) the air was examined and found to contain 3 per cent. carbonic acid.

After clearing the gasometer and hemispheres from the remaining respired air, by passing a plentiful quantity of atmospheric air through them, I left seventy-two cubic inches of atmospheric air (containing seventy-nine azote and twenty-one oxygen) until the 25th April (barometer 30·110, thermometer 70°). I then passed and repassed this air several times, and on examination found no alteration in its composition, which, by my eudiometer, was twenty-one parts oxygen and seventy-nine azote; but there was found in the hemispheres about 100 grains of pure water, which must have transpired from the leaf during this confinement.

July 25th, 1842.—Barometer 29·950. Thermometer 71°.

The experiment of the 21st of April last, as to the action of the fig-leaf on the respired air, was repeated, and on leaving, it contained 4½ per cent. carbonic acid, which on examination next morning was reduced to 2 per cent.

It will be seen from the preliminary experiments, that particular attention was paid to preserve the functions of the leaf in a healthy state, both during its inclosure and after its liberation, for in proportion as this essential condition was secured, would be our confidence in the accuracy of the results of the future proceedings for determining the action of the leaf upon a portion of atmospheric air which had served the purpose of respiration.

The conclusions drawn from the numerous experiments made during a long period are, that vegetation, particularly in fine healthy leaves, is always acting to restore the atmospheric air to its original composition of twenty-one parts per cent. of oxygen, by the absorption of the carbonic acid gas and the liberation of oxygen; that this action is accelerated by the aid of light, but that it continues even during the night, although more slowly, and that the production of carbonic acid gas is never observed to take place when the leaf is in health.

The fluid given off during the experiments, when examined, proved to be pure water; when tested by lime water it showed no carbonic acid.

The power possessed by the leaf of taking up carbonic acid gas seems very analogous to that by which food is collected by animals; the first portions of carbonic acid are more quickly taken up than the remaining portions, and one might almost say, that with plants, as with animals, at first a keen appetite is in operation, which being satisfied, is followed by repletion.